Comments on
Notice of Proposed Rule Making
Access Broadband Over Power Line Systems
ET 04-37

by
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Introduction

These comments are in response to the Commission's Notice of Proposed Rule Making (NPRM) covered in Dockets ET 03-104 and ET 004-37, covering Access Broadband Over Power Line Systems (commonly called BPL). This technology, in several variations, promises a wide impact across several fronts, and these comments are addressed to concerns that result therefrom. Although the updated NPRM is several steps in the right direction, I believe there are significant gaps that must be filled before these systems are widely deployed.

Executive Summary

In spite of assurances to the contrary, many concerns of interference from Access BPL systems remain unresolved. Far too many of these assurances are of a general, non-technical, non-quantitative nature, rather than the result of a verifiable engineering analysis or proper field measurements. Indeed, there have been reliable reports of instances of interference even by the power companies. Current Part 15 levels are, in the words of some proponents of Access BPL, "very generous". Careful consideration of the numbers indicates that some difficulties have been minimized and benefits exaggerated. I also believe that there are real and serious non-technical concerns about the widespread deployment of this technology and about the demands this might place upon the FCC. I believe that I am fully qualified to offer a technical opinion in this matter.

Technical Considerations

There have been numerous concerns expressed by licensed users of the spectrum as to the probable impact of widespread deployment of BPL technologies. The primary concern expressed is in the area of Radio-Frequency Interference (RFI)/Electromagnetic Compatibility (EMC). I believe there are solid technical reasons for these concerns.

In October, 2003, I attended a meeting of the New Orleans Section of the Institute of Electrical and Electronics Engineers (IEEE), of which I am a Senior

Member. The speaker was Dr. John Newbury, an IEEE Power Engineering Society Distinguished Lecturer, and the topic was “Broadband Power Line Carrier Communications”. Dr. Newbury is an active member of several committees developing techniques and standards for BPL. He spent considerable time on the topic of RFI/EMC and within three minutes made two statements I found interesting. He first maintained that the fears of interference expressed by radio amateurs and others was unfounded, and often the result of technical ignorance. Moments later he noted that readable signals from a BPL test conducted in London, England had been received in Rome, Italy “using a sensitive receiver”. Radio amateurs use “sensitive receivers”. In fact, it could be argued that their use is mandated by implication by the FCC requirement that amateurs use the minimum power necessary to obtain reasonable communications; a sensitive receiver means less transmitter power is required. Frankly, I am at a loss as to how a rational person can deny the possibility of interference to local communications while noting that those non-interfering communications reached from London to Rome. Since that was unintentional communications, I would define that as at least offering the possibility of interference in Rome, to say nothing of the effect in London.

Dr. Newbury and I (along with several other Section members) had a protracted discussion following the formal meeting. Among other things, Dr. Newbury posited that reasonable standards for EMI/EMC determination and signal strength measurement from extended unintentional radiators were unavailable. This is nonsense; the military has had standards for EMI/EMC levels and appropriate measurement methods available for decades. Empirical measurements of operating systems in the field are not difficult, although it does require the use of rather expensive and specialized equipment. One might suspect that the Access BPL proponents are reluctant to make and/or publicize these test results. Recently, one operator of BPL field trials has argued that people opposing the use of BPL on the basis of interference should be required to provide these measurements to prove the interference. The reality is that it is unrealistic to expect radio amateurs to obtain equipment costing several tens of thousands of dollars to make the measurements, or to have the technical knowledge to make these measurements according to industry standards, or to have the credentials that would make it likely that BPL proponents would accept these measurements if they were made. Rather, the onus should properly be put upon the manufacturers proposing these systems to demonstrate the non-interference using already standardized equipment and techniques and overseen by all interested parties.

When the requirements levied upon FCC Part 15 devices were pointed out, Dr. Newbury (who is from England) noted that the FCC was a “local” regulatory authority and suggested that the Commission would ultimately have to follow the lead of the international community (e.g., CISPR, CENELEC). Here, the concern was primarily over interference from other, licensed services <u>to</u> BPL communications, rather than interference from it, but did also include the

emission of radiation. This is in spite of statements such as the following: “Compared to the European limits currently under discussion, FCC Part 15 can be regarded as highly generous for high-speed PLC and in no way obstructing the spreading of PLC technology...”. [1] The FCC has correctly made very clear that Access BPL devices will be subject to Part 15 rules, with some clarification and updating specific to Access BPL. This is a very positive step to reduce the problems that will result. Unfortunately, however, human nature being what it is, this will not eliminate the problem.

I must also take issue with paragraph 36 of the NPRM, which states in part, “We also disagree with ARRL and others that suggest that interference caused to amateur and other radio operations by Access BPL systems complying with our Part 15 limits will be widespread. Although we agree with ARRL that Access BPL on overhead lines is not a traditional point-source emitter, we do not believe that Access BPL devices will cause the power lines to act as countless miles of transmission lines all radiating RF energy along their full length. Rather, the primary source of emissions will be the individual couplers, repeaters and other devices and, to a lesser extent, the power line immediately adjacent thereto.” Although the ARRL might not possess the theoretical expertise required to develop a realistic theoretical value for or simulation of these emissions, clearly both the Commission’s Engineering Staff and engineers for the manufacturers who are proposing Access BPL systems do, or should, have this expertise. A lack of a solid, theoretical analysis, signed by the individuals making the analysis, does not engender confidence in the statements. We are dealing with engineering here, not the reading of tea leaves.

I am therefore concerned that the Access BPL measurement guidelines fail to effectively address radiation from the power lines. It appears that the Commission had accepted without proof the assertion by the manufacturers that the primary sources of emissions are the installed devices rather than the lines themselves. Technically competent proponents of the technology do not even make that claim. For example, Reference [1] notes, “Due to the used frequency ranges, there might be considerable contributions to the far field, as the wire structures carrying the PLC signals form an antenna array. Thus, it can be expected that certain portions of transmission power are radiated via ground and sky wave, respectively. This new scenario may affect extremely sensitive shortwave radio services such as amateur radios, wireless security services, or military surveillance stations. With mass deployment of PLC, a noticeable rise in background noise appears probable.” The authors note that one study, involving only the near field, indicated no significant rise in the background noise, but then go on to say, “However, if different assumptions are made as input for simulations, the result are less optimistic regarding the EMC of PLC.” And these are the proponents.

I also find interesting the statement, in the same paragraph of the NPRM, that “In addition, as indicated above, Current Technologies, Main.Net and other Access

BPL equipment manufacturers state that in their implementations only a limited number of devices transmit simultaneously on the same frequency in the same geographic area..." This leads directly to one significant question I have not seen addressed in any BPL discussion, and that is stacking of data rates. In New Orleans, a typical residential feeder might have some 3000 customers on it. Let us assume that perhaps 15% take advantage of Access BPL services. A single feeder serves a relatively small geographic area, and there will be 450 customers accessing the system through this feeder. During peak activity, which is the evening and weekends for residential areas, say perhaps as many as 50% of the nodes will be active. I believe that any such rudimentary numerical analysis casts serious doubt on the reliability of the statement quoted above. Moreover, the trend is to use the available bandwidth more fully, with services requiring the transfer of large amounts of data (e.g., downloading of music from vendors, more complex and/or animated Web pages, etc.) This implies that there will be many users, large data loads, and high utilization of available power and bandwidth, and casts doubt upon the manufacturers' statements.

Moreover, I believe there is another problem that follows from this analysis. A common definition for Broadband access is a data rate of 2 Mbps, which is typical of many connections. If the aforementioned 450 customers are all downloading data simultaneously, this requires a data throughput of 900 Mbps over the feeder. Does anyone seriously expect an Access BPL system to carry this data rate? Or will customers be sold a Broadband connection that does not deliver broadband data rates? Of course, the feeder can be segmented with filters, thereby dividing the bandwidth requirement over the number of sections so created. However, this will require that expensive filters capable of handling hundreds to perhaps a thousand amperes at feeder voltages (typically 24 kV in New Orleans) be installed. Who will pay this cost? It should fairly be bourn by the Access BPL customers who benefit from their installation, not the electric utility ratepayers, even though it is installed on the electric distribution system. Perhaps the New Orleans City Council and Louisiana PSC will agree with that. Will the Commission propose to override their regulation of electric rates to subsidize this communications medium? Will these filters degrade reliability of the power system, particularly in the event of lightning strikes? I must assume someone in the utilities' distribution engineering staffs are overseeing the efforts of these communications companies, but I have seen no technical discussions of these questions. Perhaps the filters would be installed where laterals branch off of the feeders, but then we lose the data transmission capacity from the substation to the point of connection of the lateral, requiring fiber optic cable or other transmission medium to that point. Of course, one way around this difficulty, as the authors of [1] point out, would be to run fiber optic cables to the distribution transformer and use Access BPL for access to the home. And of course, this also eliminates most of the advantage of using the power line in the first place. Also, it still leaves the consumer with a reduced bandwidth. If the fiber is a few yards from the consumer's home, why not carry the fiber to the home, as Verizon is in the process of doing? This provides a much greater

bandwidth capacity without possibility of interference, much higher security, etc. There are also other so-called “last mile” solutions (e.g., coaxial cable, wireless methodologies), if that is all Access BPL is achieving.

I have doubts about the statements, expressed by several proponents of Access BPL technology, that this system will see wide use for control and monitoring of the power system. First, most power companies have a significant investment in SCADA systems. These are generally robust, reliable, and secure. I doubt that this will be abandoned for use of Access BPL technologies. Power companies do employ some pilot wire relaying using established methods, but this is primarily on transmission systems. There is also a security issue should this technology be employed for system control. It might have some use in providing a more granular control over the distribution system, but it remains to be seen whether this would be worth the cost. Current technologies (reclosers, VFIs, etc.) seem adequate, as I understand it from the distribution engineers I talk with.

I have two concerns specific to the distribution system (the medium voltage part of the power system under discussion). Both are due to the very real facts of construction of the distribution lines in my neighborhood. Here, there is a 24 kV line mounted on the top of the pole. This lateral is the only medium voltage conductor available. There is a shared (grounded at each pole) neutral conductor from pole to pole, located well below the 24 kV line (and also below the distribution transformer). This serves, along with earth ground, as the return for the 24 kV distribution line at the top of the pole (and it is also the neutral connection point for the transformer secondary and house drops). First, I believe the spacing here precludes the system from being considered a balanced dipole source for distances on the order of the line spacing. Moreover, the availability of multiple return paths through earth ground and wire inductance is likely to seriously disturb the longitudinal balance of currents, including injected Access BPL currents. I emphasize here that these are the only two conductors available to the power company for Access BPL in my neighborhood. Technical journals point out that “...this is a disadvantageous configuration regarding EMC.” [1] Moreover, this method of construction is common on distribution systems. My second concern is that at the frequencies under discussion, the two conductors are capable of acting as a phased array for the radiation of electromagnetic energy. Depending on the frequency of operation, spacing, power level, etc., this array might launch a significant amount of EMI in certain directions. Of course, it might also be susceptible to interference from those same directions. The proposed measurement techniques do nothing to address this matter.

There is also the aggregation of radiations. Some manufacturers have stated that there is no aggregation of interference from multiple devices. Even a cursory understanding of noise, statistical processes, and electromagnetic field theory should lead one to doubt that this statement is in fact true. Radiation from Access BPL sources IS likely to raise the general noise floor in areas where they are widely deployed. This WILL make communications more difficult, and result

in transmitting stations using more power to maintain effective communications, or render the path unusable. Of course, use of more power increases both the probability of interference to BPL and other undesirable effects. And of course, as a Part 15 device, in theory the Access BPL system must accept any interference from licensed services it receives. From the point of view of the licensed user, this is perhaps not a technical problem, but it is a very real social one. And interference will occur. I note that Chairman Powell recently visited an Access BPL demonstration site in Virginia as a "photo opportunity" for BPL. Several amateur radio operators decided to take the opportunity to speak to Chairman Powell and other FCC representatives about this technology, and concern was expressed that the amateur operators would used their mobile radios to interfere with the demonstration. Of course, the amateur operators did no such thing. But if a mobile station, with its limited power and inefficient antenna system, is a cause for concern, what about a fixed station with considerably higher power and greater antenna gain? The ARRL has very correctly expressed concern about the possible curtailment of some members' operating privileges to protect that Part 15 technology once it is installed.

The Commission asserts, in paragraph 45 of the NPRM, that measurement guidelines for the Access BPL equipments do not exist. They might not exist in the Commission's statutes, but as pointed out above, military specifications for conducted and radiated electric, magnetic, and electromagnetic radiations and susceptibility have existed for many years. Moreover, techniques for measuring field strength at a user's location are standard practice. The Commission's proposed guidelines are a worthwhile effort, but do not break new ground. For a licensed service, the true test is, what is the electromagnetic field level at the frequency or frequencies of interest at the receiving antenna, and does the received interference rise above the noise floor or to a level so as to degrade communications. It is perhaps not possible to incorporate such a non-quantitative measure in Part 15, but surely some reasonable numerical values that accomplish this can be found. Obviously, local geography, layout of the development and utility system, etc., are all highly variable and have an impact on the interference experienced. This should be taken into account. In paragraph 35 of the NPRM, there is a statement that, "We therefore would expect that, in practice, many amateurs already orient their antennas to minimize the reception of emissions from nearby electric power lines." This is of course common sense and undoubtedly true. However, there are still many amateurs who because of space and financial considerations use wire antennas and cannot orient them in an optimal fashion. They should not be unduly disadvantaged because they cannot afford a tower and beam antenna and/or larger lot of ground.

I will also note that pressures on the radio spectrum are more intense than at any pervious time in history. It seems a poor choice to unleash a technology that has significant potential to disrupt or degrade the spectrum when alternative choices are available (fiber, xDSL, etc.). Of course, Access BPL is often touted as a

solution for rural areas, requiring no new cabling infrastructure. Whether it is in fact actually used that way remains to be seen and will depend on large part on the losses encountered. Of course, long runs and higher attenuation (see discussion of distribution system designs, above) will require higher transmission power. Other technologies (including wireless technologies) are available or are becoming available to deliver broadband access to consumers, including rural consumers, without the likelihood of disruption of the RF spectrum. Unnecessary use of the available RF spectrum where technically and economically viable alternatives exist is simply bad policy.

In summary, I believe that there are significant technical grounds for concern as to the results of the widespread deployment of Access BPL technologies. Most of the assurances I have seen concerning non-interference are non-technical and/or non-quantitative. The NPRM and the modifications it proposes to Part 15 rules are a very necessary and positive step, but I do not believe they are sufficient to permit the immediate deployment of Access BPL systems.

Social and Political Issues

I also believe that there are several social and political issues that require consideration. Although I am not an expert in these areas, I would like to address several aspects of these issues that seem apparent to me.

Frankly, although I have serious technical concerns about the interference my amateur radio station might suffer from deployment of Access BPL in my neighborhood, from a social point of view I am far more concerned about the interference my station and that of other amateurs might cause **to** Access BPL. I am aware of the provisions of Part 15 as they apply to interference to a Part 15 service from a properly operating licensed service. However, I do not care to have to explain those intricacies to an irate neighbor whose Web surfing has been interrupted by my QSO. He or she is unlikely to care that it is not my fault and that the power company/Access BPL provider is responsible for solving the problem. All of the Commission regulations in the world are not going to solve this problem, and are also unlikely to convince him that it is not my fault. This burden is going to fall squarely on the shoulders of the amateur radio operators. In theory, Part 15 and some of the Access BPL requirements proposed by the Commission will ameliorate this problem. In practice, from a social point of view they are unlikely to be very effective.

For a recent practical demonstration, we need only consider the growth of cable television services. Individual amateurs did in fact experience considerable problems because of errors in the design, installation, and/or maintenance of cable systems. And in many cases, customers complaining to cable system operators about interference were told, wrongly, by the operators that the amateur was at fault. And one would expect that a cable system, whose

engineers and technicians were experienced in dealing with communications systems, would be skilled in handling such problems. In general, power company personnel have no such experience and also lack much theoretical knowledge of communications systems. The communications staffs they do have are small and experienced primarily in SCADA and microwave systems and computer networks. If an Access BPL customer calls and complains of interference from an amateur radio station, is it likely that he will be told, "It's our problem. We'll look into fixing it, but until then, you'll just have to tolerate it."? Or will he be told, "It's probably something that ham is doing. File a complaint with the FCC."? Is the Commission prepared for the complaints that might result should the ARRL's interference predictions prove accurate? How much ill will between neighbors will result from these problems? And in today's environment, we should realize that in at least a very few of these cases, violence could possibly result.

There are also security issues to consider. Although I would expect such communications to be encrypted, security is still an issue. Experience with security systems currently in place (network password protection, encryption in 802.11 schemes, and so on) has taught us that most users' systems are unprotected, either through ignorance or laziness on the part of the user. Will Access BPL users be fully informed that others can monitor their access of the Internet? Or that even if their communications are encrypted, patterns of use can be noted? Will the FCC have to create new regulations to control or outlaw such monitoring, and how will it be enforced?

I am concerned that should widespread deployment of Access BPL result in many problems and lead to these systems then being banned or highly regulated so as to reduce the revenue stream, implementers will find therein a tort against the Commission for first permitting and then banning these systems. I am not at all interested in funding a taxpayer bailout of the investment costs of these systems.

Moreover, I am seriously concerned that both manufacturers and the Commission underestimate the hostility of the power system to the proposed communications. In particular, I am concerned with conducted interference **to** the Access BPL system from other equipments. While employed as a Senior Electrical Engineer at the Naval Research Laboratory, I participated in some trials of a power line carrier system aboard an AEGEIS cruiser. Of course, the ship's electrical system was significantly different from a standard distribution network, being both much more compact and employing very different equipments. The point, however, is that no reliable communications were possible. The power system, and in particular the noise generated by some of the equipment, rendered the system unusable. The AEGEIS RADAR, in particular, totally shut down the system. Now I am fully aware that a SPY-1D RADAR does not reside on the average residential distribution system, but I do wonder if Access BPL proponents are fully aware of the rising noise levels on the

power system? Harmonic levels are an ever-growing concern for power companies. Moreover, devices such as variable-frequency motor drives are capable of generating a wide spectrum of powerful non-harmonic frequency components. These devices are becoming more common in the search for more energy efficient controls, and are even starting to be found in residential devices. What happens when such a (non-licensed) device interferes with the Access BPL service? Is the Commission planning to play referee here? Or extend its authority to non-communications devices which connect to the power grid? Should Access BPL systems experience this interference, there will be significant political pressure on the Commission to undertake this role. Perhaps the Commission would welcome such a mandate and a chance to expand its purview and bureaucracy; I do not know. But I confidently predict that a rather large can of worms will be opened here.

Once such a system is deployed, Pandora's Box will be opened. Should even some of these predictions prove accurate, the Commission (as well as the implementers, service providers, and other users of the spectrum) will spend a large amount of time and resources tracking down problems and resolving difficulties. Moreover, I suggest that early adopters will adopt a strategy or offering service are a low price in order to rapidly develop a large user base. These users will become a significant political force once vested in the system. If and when problems occur, they will undoubtedly lobby to have the burden of solving the problem shifted to others rather than to the Access BPL system, where it belongs. This Commission, or it's successors, will have to deal with this, as will we all.

My Qualifications in this Area

So that the Commission may make an appropriate judgment as to what weight to give to my opinions on this matter, I will very briefly summarize some of my qualifications. I hold two B.S. degrees (in Physics and Engineering Sciences), an M.S degree (Engineering), and a Ph.D. (Electrical Engineering). The doctorate is from the University of Illinois, which is generally recognized as an excellent engineering school. I am, and have been for over 20 years, a Registered Professional Engineer in Electrical Engineering in the State of Louisiana. I am on the NCEES Committee that writes the Electronics, Controls, and Communications depth exam taken by some candidates for registration as a Professional Engineer in Electrical Engineering in all 50 states. I am a Senior Member of IEEE. I hold an Extra Class Amateur Radio License (K5FBG) and a General Radiotelephone Certificate (originally First-Class Radiotelephone Certificate) with Ships Radar Endorsement. Between degrees and during graduate school I worked as a Broadcast Engineer at WWL-AM/FM/TV in New Orleans. I have over 30 years experience in electrical engineering. I have been employed at Litton Data Systems as a Senior Engineer, Principal Engineer, and Engineering Specialist. At Litton DSD I designed part of the communications

system for Royal Saudi Army Air Defense system and high-speed fiber-optical and free-space LASER communications systems. I also was involved in the preparation of EMI/EMC analyses for military systems. I have been an Assistant Professor and Adjunct Professor of Electrical Engineering at the University of New Orleans (where I taught both undergraduate and graduate courses in power systems, among other subjects) and an Adjunct Professor at Tulane University. I have been a Senior Electrical Engineer at the Naval Research Laboratory at Stennis Space Center, where my assignments included RF system designs. I am currently a principal at Omni Technologies, Inc. in New Orleans. At OTI, we do advanced consulting for clients such as the U.S. Navy (NRL, NavO, NavSea, etc.), NASA, and other commercial clients. I have done modeling and simulation of the power system and various communications systems. I have received a NASA Space Act Award and the IEEE Millennium Medal and hold two U.S. patents. I believe I am qualified to offer the technical opinions I have expressed here.

Conclusion

I believe that there are reasonable grounds for serious concerns, of both a technical and non-technical nature, for the near term deployment of Access BPL systems. I believe Access BPL is a solution in search of a problem, and that it is more likely to be deployed in urban rather than rural areas. Should the Commission nonetheless decide to permit widespread use of BPL, I urge it to commit the resources which are likely to be necessary for enforcement of its requirements and for swift resolution of any problems or conflicts which might arise, while continuing to protect the interests of licensed services.

Respectfully submitted,
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[1] Gebhardt, Martin, Frank Weinmann, and Klaus Dostert, “Physical and Regulatory Constraints for Communications over the Power Supply Grid”, *IEEE Communications Magazine,* May, 2003, pp. 84-90

NB: There are numerous technical and semi-technical references that make the same points cited in Reference [1], above. I cite this one repeatedly because it covers most of the points I wish to make succinctly with reference to a single source. Other sources support the statements quoted from this reference.